cases, while illuminating only the back of its head quickened its heart rate. When the frog was anesthetized, no effect was found. Similar results were found in experiments done previously at higher intensities in rabbits (Presman and Levitina 1962a,b).

Serkyuk exposed rabbits to 2375 MHz waves for 60 days. Exposure to 0.06 uW/cm^2 caused slowing of the heart rate and changes in the EKG (McRee 1980).

Frey and Seifert (1968) showed that the heart is most vulnerable to microwaves at particular times during its rhythm. They illuminated frog hearts with pulsed 1425 MHz waves at an average power density of 0.6 uW/cm^2. When the heart was illuminated with a pulse 200 milliseconds after the P wave, the beat rate increased. In half the cases arrhythmias occurred. Occasionally the heart stopped. Later experiments found a similar effect with live frogs at 3 uW/cm^2 (Frey 1988).

See Frey (1988) for a good review of other research.

3. <u>Cancer</u>

Good research on microwave cancer is sparser but fairly conclusive.

Guy and Kung exposed 200 rats to pulsed 2450 MHz waves at 480 uW/cm^2 for 23 hours a day. They developed two and a half times as many cancers over their lifetime under normal life conditions as 200 unexposed controls (discussed in Frey 1994 and Szmigielski 1989a,b).

Balcer-Kubiczek (1994) proved microwaves are carcinogenic by using the C3H/10T1/2 mouse embryo cell line. This cell line is frequently used in cancer research to identify chemical carcinogens. 2450 MHz pulsed waves were used. When irradiation was followed by treatment with a known tumor promoter, TPA, it caused cancers in a dose-response relationship, similar to that seen with ionizing radiation. TPA by itself did not cause any tumors. This author concludes that "2.45 GHz microwaves seem to act as an initiator or carcinogen, rather than as a promoter of malignant transformation" (p. 150). 0.1 W/kg was effective.

Several epidemiological surveys have been combined with field measurements of radiation levels. In Honolulu, which has the highest radiation levels of any U.S. urban area (Microwave News, Jan./Feb. 1985), the State Health Department compared the cancer incidence of nine census tracts that include broadcast towers with that of two demographically similar tracts that do not. The U.S. Environmental Protection Agency measured radiofrequency intensities, which were below 100 uW/cm^2 almost everywhere in the exposed tracts. Cancer, and especially leukemia, was significantly more common in the tracts with towers (Goldsmith 1995, 1996, Marino 1988).

Hocking and Gordon (1995) report on a similar study in Sydney, Australia. They compared cancer incidence and mortality from 1972-1990 in six northern Sydney municipalities, three of which immediately surround transmitters for 4 TV stations and an FM radio station, and three of which are more distant. Exposed children had double the rate of leukemia compared to children in the unexposed communities. Radio wave intensity was 0.2-8.0 uW/cm^2 near the towers, and 0.02 uW/cm^2 in the distant communities.

Dr. William Morton of the University of Oregon's Health Sciences Center in Portland has found similar trends in his study of cancer and broadcast radiation in Portland, where levels in excess of 100 uW/cm^2 occur in some public areas and in private homes (Marino 1988, Microwave News, Nov./Dec. 1995).

Szmigielski (1996) did a controlled retrospective study of cancer incidence in all Polish military career personnel from 1971 to 1985. This included on average 128,000 persons per year. Personnel exposed to microwaves (generally less than 200 uW/cm^2) had more than double the cancer rate of everybody else. Leukemia was more than eight times as common.

For reviews of other research, see Frey (1994), Szmigielski (1988, 1989a,b), Savitz (1987), and Goldsmith (1995, 1996).

4. Reproduction

Even extremely low levels of microwaves can cause miscarriage, altered sex ratios, birth defects, and other effects on reproduction.

Ouellet-Hellstrom and Stewart (1993) did a case-control study of over 6600 pregnancies among female members of the American Physical Therapy Association. Those who administered microwave diathermy in the six months prior to or during their pregnancy had more than three times as many early miscarriages as unexposed therapists. The risk increased with increasing numbers of exposures.

Huai (1979) found abnormal menstruation three times as often in microwave-exposed workers as in unexposed workers.

The ongoing study in Latvia has found up to 25% fewer boys in certain school grades in the area that has been exposed to the radar since 1971 (Kolodynski and Kolodynska 1996).

Navakatikian and Tomashevskaya (1994) found a decrease in testosterone in rats exposed to pulsed or continuous 2450 MHz waves at an intensity of 100 uW/cm^2. They review a study by Mikolaichyk which found changes in FSH and LH in the hypothalamus of rats from a single exposure to 10 uW/cm^2.

Krueger and Giarola (1975) exposed laying hens to 260 MHz waves for 16 weeks at an intensity of 5-125 uW/cm^2. Egg production was 20% less, a greater percentage of females were hatched, and egg shell quality deteriorated.

Bigu Del Blanco et al. (1973) found a 14% increase in egg production by hens exposed to continuous 7 GHz waves at

1-400 uW/cm^2. The mortality rate of the irradiated chickens also doubled.

Kondra et al. (1970) found that 6 GHz continuous waves stimulated ovulation in hens at an intensity of 0.02 pW/cm^2 (0.00000002 uW/cm^2!). Hens that were so treated from birth showed significantly higher egg production during their egg-laying life, and significantly lower egg weight than the untreated birds. This experiment was designed to simulate the exposure at ground level to the Canadian population from a typical microwave relay tower. It was conducted in Manitoba in the late 1960s. Most places on earth have higher ambient microwave levels than that now.

A later experiment by the same authors (Kondra et al. 1972) did not appear to confirm these findings, but an examination of the data reveals that the chicks in the second experiment were kept in the light 24 hours a day for the first three weeks of their lives, and that continuous lighting stimulated ovulation to approximately the same extent as the very low levels of microwaves.

These experiments are food for thought for anyone who wonders why twentieth century human females are ovulating at ever earlier ages.

Tofani et al. (1986) exposed pregnant rats to 27.12 MHz continuous waves at an intensity of 100 uW/cm^2. Half of the pregnancies miscarried before the twentieth day of gestation, compared to only a 6% miscarriage rate in unexposed controls. 38% of the viable fetuses had incomplete skull formation, compared to less than 6% of the controls. There was also a change in the sex ratio, with more males born to rats that had been irradiated from the time of conception.

Il'chevich and Gorodetskaya report that 10 uW/cm^2 decreased litter size in mice and increased the number of stillborns (McRee 1980).

Gordon (1974) reviews other similar research in the former Soviet Union.

5. <u>Genetic damage</u>

Garaj-Vrhovac et al. (1987) found chromosome breaks, fragments and deletions in up to 13% of cultured lymphocytes of 50 workers operating microwave equipment. Unexposed workers did not have these types of lesions. These researchers write that microwave radiation is "a known mutagenic agent . . . Its damaging effects on the living organism are well known" (Garaj-Vrhovac et al. 1991).

At Skrunda, Balode et al. (1996) has found chromosome damage in cows grazing in the radiation zone. Micronuclei were counted in the red blood cells. Six times as many micronuclei were found compared to nearby cows unexposed to the radar.

Ockerman has found chromosome damage in 16 electrically sensitive people in a study not yet published (Kauppi 1996).

Goldsmith (1995) reports that significant chromosomal abnormalities were found in the blood of half the U.S. Embassy workers in Moscow in 1966. The irradiation of the embassy caused concern at official levels, and the health of these workers was monitored as part of a classified study called Project Pandora. The chromosomal and other findings, including evidence of increased rates of cancer, have since been declassified under the Freedom of Information Act.

Manikowska-Czerska, Czerski and Leach, at the U.S. Public Health Service in Rockville, Maryland, irradiated mice for 30 minutes a day for 2 weeks at an intensity of about 250 uW/cm^2 at various frequencies (Lerner 1984, reporting on a meeting of the Bioelectromagnetics Society). Chromosomal defects were induced in 7.2% of the sperm precursor cells, compared with .05-.07% in unexposed mice. This is not a dose-response phenomenon. Chromosomal damage occurred at the same rate, or even less often, at much higher intensities. Mays Swicord, at the same meeting, presented evidence that DNA could absorb 400 times as much energy from microwaves as water due to molecular resonance (see Sagripanti and Swicord 1986).

Kapustin et al. found chromosome damage in the bone marrow of rats exposed to 12-cm waves at an intensity of 50 uW/cm^2 for 7 hours a day for 10 days (McRee 1980).

Belyaev et al. (1992) found that 41 and 51 GHz waves at an intensity of 1 uW/cm^2 suppressed repair of X-ray damaged chromosomes in E. Coli. One 5-minute exposure to the microwaves prevented repair for the hour and a half of the incubation experiment. At 0.1 uW/cm^2 the effect was less pronounced.

Lai and Singh (1995) found chromosome breaks in rat brain cells at higher intensities than I am reporting on elsewhere (1-2 mW/cm^2), but these experiments are significant in finding chromosome breaks immediately upon exposure. Sarkar (1994) also found significant chromosome damage in the testes and brain of mice at these intensities.

Akoyov (1980) reported that the dose necessary to damage chromosomes was significantly smaller in live animals than in cell cultures.

A review of earlier research can be found in Heller (1969).

6. Effects on growth and aging

Numerous researchers have found adverse effects of various frequencies of microwaves on animal growth. Giarola et al. (1971, 1973) found 14-500 uW/cm^2 depressed the growth of chickens and baby rats. Gabovich et al. (1979) obtained a similar result with young rats at 100 uW/cm^2, as did Ray and Behari (1991) at 600 uW/cm^2. Gabovich (1979) reported reduced weight increase in pregnant rats at 100 uW/cm^2. Bigu Del Blanco et al. doubled the mortality of chickens at less than 400 uW/cm^2. And Garaj-Vrhovac et al. (1991) found only

60% of the normal number of Chinese hamster cells after exposing the culture to 500 uW/cm^2 for 60 minutes.

The evidence on plants is startling:

Trees growing in pine forests exposed to the Skrunda radar have had decreased thickness of growth rings beginning after 1970, which coincided with the start of operation of the radar. Nearby unexposed trees have not been similarly affected (Balodis et al. 1996).

Study of pine needles and cones at Skrunda has revealed accelerated resin production and premature aging of pine trees in the exposed area, even where the intensity is only 24 pW/cm^2 (0.000024 uW/cm^2), as compared with trees in nearby unexposed areas. Also, the germination of low exposure seeds is enhanced, while the germination of higher exposure seeds is severely impaired. The authors have noted a similarity to the effects of ultraviolet radiation (Selga and Selga 1996).

Duckweed plants grown near the Skrunda radar have a shorter life span and impaired reproduction compared to plants grown distant from the radar. Morphological and developmental abnormalities are also found in the exposed plants (Magone 1996).

Marha (1969) writes, "It is known from reports in the literature that the velocity of cell division with Vicius fabus [a bean] is accelerated at field intensities of 10^{-4} V/m at frequencies of approximately 30 MHz and the velocity decreases at values above 0.1 V/m" (p. 189). 10^{-4} V/m corresponds to a power density of 0.0026 pW/cm^2 (0.0000000026 uW/cm^2). This is less than what we receive on earth from satellites. These experimental results, and those from Skrunda, and those of Kondra with chickens, above, prove that satellite signals are biologically active.

7. <u>The blood and immune system</u>

<u>Blood cells</u>. The immune response is often biphasic: stimulated at low intensities and inhibited at higher intensities.

Chiang et al. (1989) in their epidemiological study found that white blood cell phagocytosis was stimulated by chronic exposure to the lowest intensities of radio waves and inhibited, sometimes severely, by higher intensities. The subjects were students in kindergarten, secondary school, and college who were exposed to radio transmitters or radar installations at school. Exposure levels ranged from 0-4 uW/cm^2 to 120 uW/cm^2.

Goldoni (1990) examined air traffic controllers at a two year interval and found, in almost all cases, a significant decrease in white blood cells and platelets during their two years on the job. White blood cell count was below normal after two years in 36% of the workers. Red blood cell counts were lower on average than the control group and sometimes sub-normal.

Huai (1981) also found an average decrease in white cells and platelets among microwave workers.

Sadchikova (1974) found changes in the same directions in 1180 workers.

Near the Skrunda radar, the 230 people examined had significant increases in their white cell counts and alterations in differential counts. Children were most affected. The irradiated Moscow embassy workers had an increased hematocrit, a strikingly higher white cell count and other changes that progressed during the time of their exposure (Goldsmith 1995).

Zalyubovskaya and Kiselev observed 72 microwave-exposed engineers and technicians over a period of 3 years. Their exposure level occasionally reached 1000 uW/cm^2. During the

3 years, red blood cells and hemoglobin content of the blood declined, reticulocytes and platelets were reduced, white blood cells dropped to 30% below the control group, and lymphocytes increased 25%. The number of bacteria in the mouth was considerably higher and the bactericidal activity of the skin was less. These and other changes in immune function were then confirmed by experiments on mice. The animals were exposed to comparable intensities as the workers for 15 minutes a day for 20 days. The mice also developed 1/3 to 1/2 fewer antibodies in the blood, had lower resistance to infection, and a decrease in the size of their thymus, spleen, and lymph nodes.

Zalyubovskaya and Kiselev also noted an 18% decrease in the osmotic resistance of red blood cells and a 26% decrease in their acid resistance, in the exposed workers. This brittleness of red blood cells upon exposure to electromagnetic fields has been noted by others (Dodge 1969, Sadchikova 1974) and recently confirmed by Ockerman (Sodergren 1996, Kauppi 1996).

Lysina wrote that basophilic granularity of erythrocytes should be taken as an early sign of microwave effect on the human organism (Dodge 1969, p. 145).

Bachurin (1979) found that chronic exposure to 20-60 uW/cm^2 increased the frequency of influenza, tonsillitis and other illnesses among workers.

See Drogichina (1960), Sokolov and Arievich (1960), and Dodge (1969) for a review of other clinical studies showing similar changes in the blood elements.

Shandala et al. (1979) found that 2375 MHz at 500 uW/cm^2 caused a sudden significant impairment of immune function in rabbits. Animals exposed for 7 hours a day for 3 months did not recover normal immune function for 6 months afterwards. At 10 and 50 uW/cm^2 immunity was stimulated.

These results were further refined by a 30-day experiment with guinea pigs at 1, 5, 10, and 50 uW/cm^2 (Shandala and

Vinogradov 1978). All these intensities increased complement in the blood and stimulated phagocytosis by neutrophils, but 1 uW/cm^2 had the biggest effect, and 50 uW/cm^2 the smallest effect. Two months later the animals that had been exposed to 10 and 50 uW/cm^2 had an impaired response to hypoxia, and to injection of foreign protein.

These researchers also established that at 50 uW/cm^2 the radiation promotes autoimmunity by altering the antigenic structure of tissue and serum proteins. This was confirmed by Gabovich et al. (1979).

Other similar work has been done by Shutenko et al. (1981), Veyret et al. (1991), Ray and Behari (1990), Shandala and Vinogradov (1983), Chou and Guy (Lerner 1984, p. 64), and Marino (1988). Dumanskij and Shandala (1974) noted effects even at 0.06 uW/cm^2. Elekes et al. (1994) found an increase in antibody-producing cells in the spleen of mice at 30 uW/cm^2, and noted the relevance of their study to mobile communications.

Blood sugar. Out of 27 exposed workers, 7 had flat blood sugar curves, 7 were prediabetic, and 4 had sugar in their urine (Bartonicek et al., summarized in Dodge 1969). Gel'fon and Sadchikova (1960), Sadchikova (1974), and Sikorski and Bielski (1996) report similar findings. Klimkova-Deutschova (1974) found a slight increase in the fasting blood sugar in 74% of workers.

These reports are consistent with animal experiments showing disturbed carbohydrate metabolism. Dumanskij and Shandala (1974), at 0.06-10 uW/cm^2, found decreased mitochondrial activity of cytochrome oxidase, decreased glycogen in the liver, and accumulation of lactic acid. This pattern had been confirmed by later experiments (Dumanskiy 1976, 1978, 1982a,b) and by other researchers (Gabovich et al. 1979, Belokrinitskiy 1982, 1983, Shutenko et al. 1981, Dodge 1969).

Navakatikian and Tomashevskaya (1994), at 100 uW/cm^2, report decreased serum insulin in rats.

<u>Cholesterol and triglycerides</u>. Microwaves caused an elevation in blood cholesterol in 40.9% of exposed workers vs. 9.5% of controls, in agreement with reports by other researchers. Beta-lipoproteins were also elevated. (Klimkova-Deutschova 1974).

Sadchikova et al. (1980) found elevated triglycerides in 63.6% of exposed workers and elevated beta-lipoproteins in 50.2%. A direct relationship was found between hyperbeta-lipoproteinemia and retinal angiopathy. Higher cholesterol and phospholipids were also found in the exposed workers compared to the controls.

<u>Serum proteins</u>. Changes in serum proteins have been noted by many in clinical studies. It is found that microwaves cause an increase in total blood proteins and a decrease in the albumin-globulin ratio. See Pazderova et al. (1974), Sadchikova (1974), Klimkova-Deutschova (1974), Dodge (1969), Gel'fon and Sadchikova (1960). Drogichina (1960) writes that these are signs of the early influence of microwaves, before clinical signs of disease are evident.

<u>Other biochemistry</u>. Gabovich's rats (1979) had elevated ascorbic acid in their urine and adrenals.

Dumanskiy and Tomashevskaya's rats (1982a,b) had elevated blood serum urea and residual nitrogen from exposure to 8 mm or 3 cm waves at 60 uW/cm^2. This reflected disturbed protein metabolism. Gabovich's findings of high ascorbic acid in the adrenals was also confirmed.

8. <u>Cataracts</u>

In the early 1970s the U.S. Army undertook an ophthalmological study of employees at Fort Monmouth, New Jersey, a facility where electronic communication, detection, and guidance equipment are tested, developed and used. Workers exposed to microwaves had substantially more lens opacities than the controls (Frey 1985).

Huai (1979) found more lens vacuoles in irradiated workers than in controls. The tendency was evident even in those exposed to less than 200 uW/cm^2, and became statistically significant at higher intensities. A few cases of cataracts were found in the microwave workers.

Bachurin (1979) noted a greater incidence of points of turbidity of the lens, narrowing of the arteries, spasm of vessels, and beginning sclerosis and angiopathy of the retina. These were young men working in TV and radio installations and other facilities where microwave intensities fluctuated between 20 and 60 uW/cm^2, only occasionally reaching 100 uW/cm^2.

Sadchikova (1974) and Sadchikova et al. (1980) noted angiopathy or sclerosis of retinal blood vessels in workers exposed to several hundred uW/cm^2 in radar production shops.

Drogichina (1960), 20 years previously, had noted both angiopathy of the retina and opacifications of the lens in microwave workers.

In 1969 Zaret studied 736 radar workers and 559 controls, and found significantly more lens opacities in the radar workers. Belova's study of 370 microwave workers, Majewska's study of 200 microwave workers, and Janiszewski and Szymanczyk's study at the Institute of Aviation Medicine in Warsaw all yielded similar results. Zydecki found an increased frequency of lens opacities in 3000 microwave workers who were never exposed to thermal intensities and concluded that microwaves prematurely age the lens. Baranski and Czerski, reviewing this study (1974), stress that "the statistical treatment of data is extremely careful and does not leave room for doubts" (p. 167).

9. <u>Internal organs</u>

The thyroid gland is one of the most sensitive indicators of microwave influence. Animal experiments show increased activity and/or enlargement of the thyroid at 153 uW/cm^2 (Demokidova 1973), at 100 uW/cm^2 (Gabovich et al. 1979, Navakatikian and Tomashevskaya 1994), and at 1 uW/cm^2 (Dumanskiy and Shandala 1974). Several clinical studies confirm this (Drogichina 1960, Sadchikova 1960, Smirnova and Sadchikova 1960, Baranski 1976). Smirnova states that physiological and even pathological changes in the activity of the thyroid can be detected long before any clinical manifestations of microwave injury. In this study 35 out of 50 persons working with microwave equipment showed abnormal thyroid activity. Drogichina reports increased thyroid activity in almost all microwave workers examined.

The adrenals are also extremely sensitive to radiation. In animals irradiated for from 2 months up to 2 years, the adrenals are generally enlarged, have an altered ascorbic acid content, increase the secretion of adrenalin and glucocorticoids, and decrease the secretion of testosterone: Chou and Guy at 500 uW/cm^2 (Lerner 1984), Navakatikian and Tomashevskaya (1994) at 100 uW/cm^2, Gabovich et al. (1979) at 100 uW/cm^2, Dumanskiy et al. (1982) at 25 uW/cm^2, Shutenko et al. (1981) at 10 uW/cm^2, Dumanskij and Shandala (1974) at 0.06 uW/cm^2. With a shorter exposure, Giarola et al. (1971) found a decrease in the mass of the adrenals in chickens at 14-24 uW/cm^2. In clinical studies, Sadchikova (1974) noted altered excretion of epinephrine and norepinephrine; Kolesnik et al. noted a decreased blood 17-CHS response to ACTH injection in all 35 workers tested (Baranski and Czerski 1976); Hasik, and also Presman, noted increased activity of the adrenal cortex (Dodge 1969).

Ray and Behari (1990) found a significant decrease in the weight of the spleen, kidney, brain and ovary, and an increase in testicular weight in young rats exposed to 7.5 GHz, 600 uW/cm^2, 3 hours a day for 60 days.

Dumanskij and Shandala (1974) found increased RNA and DNA in the liver and spleen, and structural changes in the liver, spleen, testes, and brain of white rats and rabbits exposed to 3 cm and 12 cm waves at 0.06 to 10 uW/cm^2 for 8 to 12 hours a day for 180 days.

Giarola et al. (1971, 1973) report an enlarged spleen and thymus in baby rats exposed for 35-53 days to 880 MHz, 14 uW/cm^2.

Erin' (1979) reports a 23-83% increase in oxygen tension in renal tissues of adult white rats exposed to 2375 MHz, 50 uW/cm^2 for 1-10 days.

Belokrinitskiy (1982) observed changes in the biochemistry and ultrastructure of liver, heart, kidney and brain tissue in rats exposed to 12.6 cm waves at intensities of 5 uW/cm^2 and higher for up to 2 months.

50 uW/cm^2 for 7 hours a day for 10 days caused urine output to fall 15%, and 500 uW/cm^2 once for 7 hours had a larger effect (Belokrinitskiy and Grin' 1983). Elevation of urine pH, protein in the urine, and changes in electrolyte excretion persisted up to 25 days after exposure. Examination of kidney tissue revealed vasodilation, endothelial breakdown, perivascular and pericellular infiltrations, hemorrhage, swelling, partial de-epithelialization along the nephron, and other changes. Histochemical analysis showed decreased cellular glycogen, changes in RNA and DNA concentration, and the appearance of neutral fat droplets. Some of these changes were irreversible, even two months after one 7-hour exposure.

In large clinical studies, Orlova (1960) noted decreased appetite, indigestion, epigastric pain, and enlargement of the liver in irradiated workers, while

Gel'fon and Sadchikova (1960) also noted liver enlargement and tenderness in certain patients, with a decreased antitoxic function of the liver in a few. Trinos (1982) noted decreased appetite and indigestion, as well as chronic gastritis, cholecystitis, and decreased gastric acidity, especially in workers exposed to microwaves for more than ten years. Bachurin (1979) also noted chronic gastritis and cholecystitis in workers occupationally exposed to 20-100 uW/cm^2.

10. <u>Lungs</u>

Shortness of breath has already been mentioned as part of radiation sickness and is probably cardiac related. The ongoing study in Skrunda has also revealed a decreased pulmonary function in exposed children (Levitt 1995). And an experiment with rats (Gabovich et al. 1979) revealed 7.7% decreased oxygen consumption during a 10-week exposure to 2375 MHz at 100 uW/cm^2. See the discussion of hypoxia, below, under "Mechanisms".

11. <u>Bone marrow</u>

Kapustin et al. found chromosome damage in the bone marrow of albino rats at 50 uW/cm^2, as was discussed previously. The damage was higher 2 weeks after irradiation than immediately (McRee 1980).

Sadchikova (1974) found signs of stimulated erythropoiesis in the bone marrow of young men occupationally exposed to microwaves. So did Sevast'yanova and Vilenskaya in animal experiments with millimeter waves, which penetrate less than 1 mm into the body and do not reach the bone marrow (Akoyev 1980).

12. Hair and nails

Radiation sickness also causes hair loss and brittle fingernails (Dodge 1969, Inglis 1970, Huai 1979).

13. Synergistic effects

Low intensity microwave radiation increases the effects of morphine (Frey 1994).

It modifies the effects of librium (Frey 1994).

It increases the effects of Haldol (Frey 1994).

It counteracts the effects of amphetamine (Frey 1994).

It increases the toxicity of formaldehyde and carbon monoxide. Formaldehyde and carbon monoxide increase the sensitivity of the body to microwaves (Shandala and Vinogradov 1978).

It increases the toxicity of Cardiazole (Baranski and Czerski 1976, p. 163-4).

High temperatures or hypoxia increase sensitivity to microwaves (Baranski and Czerski 1976, p. 75).

14. Microwave hearing, and other sensing

"The perceptibility of radiofrequency fields is the most thoroughly established datum in the behavioral literature on such radiations" (Justeson 1979, p. 1061-2). Pulsed microwaves can be heard by most individuals as buzzes, hisses, chirps, pops, or clicks, provided the pulses have sufficient peak energy. The average power density need be only 2 or 3 uW/cm^2. Peak power goes totally unregulated by industry or government, and even the voluntary standard "is well above the threshold for auditory effect" (IEEE 1991, p. 33-34). Since virtually all cellular broadcasts are soon to be digital and pulsed, we may expect this sort of chronic nuisance to become much more widespread. Auditory sensitivity to microwaves varies enormously; already there have been reports of suicides by extremely sensitive individuals. This author is among those who hear electromagnetic radiation at present ambient levels.

The presently accepted explanation for this phenomenon is that pulsed radiation creates thermoacoustic pressure waves in your brain. These pressure waves reach your inner ear where the vibrations are heard like any other sound. Thus the assumption that microwaves will not harm you if they aren't strong enough to cook you has taken a strange twist. But more on that later.

For extensive reading about the microwave hearing phenomenon, see Frey (1963, 1969, 1971, 1973, 1988), Olsen (1980), Olsen and Hammer (1980), Justeson (1979), Wieske (1963), and the book by Lin (1978).

Frey and co-workers also demonstrated that animals will avoid pulsed microwaves when they are able to do so. In one experiment rats spent only 30% of their time in the illuminated half of their box and 70% of their time in the shielded half. The frequency was 1.2 GHz, average power 200 uW/cm^2 and peak power 2.1 mW/cm^2 (Frey and Feld 1975, Frey, Feld and Frey 1975). Frey also demonstrated avoidance of microwaves by cats (Frey 1969, Frey and Feld 1975).

At relatively high intensities at 10 and 16 GHz, Tanner et al. (1966, 1967, 1970) found that chickens, pigeons, and seagulls showed great distress and collapsed within a few seconds. Intrigued by the fact that birds reacted this way when irradiated from above and not from below, and by the fact that defeathered hens showed no such distress, these authors postulated that feathers serve as dielectric aerials in the microwave region. They subsequently designed experiments which proved that bird feathers indeed make fine receiving aerials for 10 GHz waves (Bigu Del Blanco et al. 1973). Their work has serious implications, because virtually all radars, television and radio antennas, and wireless communication transmitters are aimed above the horizon where the birds fly. The microwave density increases with height, and must cause enormous suffering. There have been many anecdotal reports of birds leaving the area after a cellular tower goes into operation (Hawk 1996).

Finally, in a study of anteaters, Kholodov reports that they lost their ability to "inform" other anteaters about a food source during microwave irradiation, and furthermore that they oriented their snouts along a particular axis during the irradiation. Power levels were not stated (Inglis 1970).

15. <u>Electrical sensitivity</u> (ES)

Electrical sensitivity is a new name for radiation sickness, so-called because many sufferers become aware that electromagnetic fields make them ill and they experience symptoms immediately upon exposure. For many, including this author, it is like developing a new sense. Sensitivity may develop to any type of radiation including that from power lines, microwaves, X-rays, and radioactivity. Modern society may become intolerable and even ordinary sunlight may cause illness. The degree and range of sensitization depend on both the source of the injury and the susceptibility of the individual.

Baranski and Czerski (1976) write, "In certain instances syndromes of neurological disturbances (without organic lesions) and signs of neurosis, accompanied by a poorly expressed bioelectric function of the brain, are found in microwave workers following long periods of exposure. These patients may be incapacitated for further work and even normal everyday life" (p. 164).

In a controlled double blind clinical study, Rea et al. (1991) proved that electrically sensitive patients could perceive low level radiation. These researchers used 0.1 Hz to 5 MHz magnetic fields with a field strength of 70-2900 nT.

Ockerman compared 16 electrically sensitive patients with 10 healthy volunteers, and demonstrated clear differences in the red and white blood cells and urine, as well as chromosome damage, in the electrically injured group (Kauppi 1996, Sodergren 1996).

Johansson and Liu (1984) found specific changes in the skin of electrically sensitive patients: remarkably high numbers of somatostatin immunoreactive dendritic cells and histamine positive mast cells.

Huai (1981) writes that "those syndromes are not easy to recover" (p. 636).

It has been estimated from limited survey data that 2% of the population is susceptible to becoming electrically sensitive (Firstenberg 1996). This estimate comes partly from medical statistics on porphyria, which is prevalent in the electrically injured (see below). In agreement with this figure, Sadchikova (1960) reported that 11 of 525 people, or about 2%, had to cease working under conditions of microwave influence.

A higher estimate of 15% comes from a survey of 731 employees at 5 Swedish workplaces (Knave 1992). The source of radiation here is video display terminals. The 15% figure also receives support from earlier research. Sadchikova (1960) reported that radiation sickness had arisen after 3 years of work in 15% of employees, and in later work (1974) the same author writes that its frequency "did not exceed 15%." Klimkova-Deutschova (1974) found synchronized activity on the EEG in 14.3% of workers at a radio transmitting station.

It may be supposed from the above data that 15% of people exposed to microwave radiation develop overt symptoms, and that in 2% the changes become irreversible.

In controlled clinical experiments, Leitgeb (1994) found 2.3% of a random population in Graz, Austria were hypersensitive to electric currents, and Szuba and Szmigielski (1994) found 2 out of 71 healthy volunteers were hypersensitive to power line radiation, as evidenced by a marked delay in auditory and visual reaction time. Hanson (1995) found electromagnetic hypersensitivity in 12 of 519 dental patients, again a 2.3% rate. In 1981 Cabanes and Gary found 3 of 75 healthy male volunteers were able to perceive extremely low exposures to power line radiation (reviewed by Szuba and Szmigielski).

There are animal models for ES. Salford et al. (1993), testing for carcinogenicity of microwaves in rats (915 MHz, specific absorption rate of .0077-1.67 W/kg), noted that "for some modulation frequencies the average tumor size in the exposed animals largely exceeds the average size in the controls. . . This might indicate that in the few animals that, for some reason, are sensitive to the exposure, tumour growth is stimulated strongly" (p. 317).

Frey (1988) found that living in an electromagnetic field increased emotionality in test animals, and that "some animals were particularly sensitive to exposure to such fields (p. 802). He also found, in other experiments, the responses to radiofrequency radiation were bimodally distributed, again calling "attention to the importance of individual differences in sensitivities when low-intensity radiofrequency radiation is used" (p. 804).

Animal sensitization has also been demonstrated. Shandala et al. (1979), in a chronic exposure experiment on rats and rabbits (2375 MHz, 10, 50 and 500 uW/cm^2), found a substantially lower threshold of skin sensitivity to electrical stimulation and a decrease in the "electronic irradiation threshold."

16. Diagnosing ES: a guide for doctors

The clinical studies reviewed in this booklet report the following early signs of radiation injury:

(1) change in olfactory sensitivity, which (if low) a single dose of caffeine may restore to normal

(2) increased thyroid activity and/or enlargement of the thyroid gland

(3) elevated serum protein and globulin, and lowered albumin/globulin ratio

(4) elevated histamine in the blood

(5) a weakened cutaneous vascular reaction to histamine

(6) basophilic granularity of erythrocytes

(7) decreased osmotic and acid resistance of erythrocytes

(8) mild leukopenia and thrombocytopenia

(9) immunoglobulins at the lower limit of normal

(10) bradycardia and/or hypotension

(11) lengthening of the intraauricular and intraventricular conduction of the heart on EKG, also a decrease in the amplitude of the R and T teeth, which may show up only upon physical stress

(12) subclinical activity on the EEG; the appearance of pointed synchronized waves of high amplitude and increase in slow (delta and theta) waves. These changes may appear only after activation by hyperventilation.

(13) on neurological exam: tremors of the eyelids and hands, increased tendon reflexes, decreased abdominal reflexes

(14) abnormalities in the blood sugar curve, and slight increase in the fasting blood sugar

(15) increase in cholesterol and beta-lipoprotein

(16) increased or decreased serum lactic acid

(17) acrocyanosis

Sodergren (1996) in his forthcoming study is expected to report on specific changes in the urine, as well as in the red and white blood cells.

In view of the expected metabolic hypoxia (see below), changes in the blood oxygen content and pH might also be sought.

Low values for red blood cell copper have also been seen in electrically sensitive patients, in accord with the expected redistribution of metals in the body (see below).

Kowalski and Indulski (1990) discuss psychological tests which detect early disorders of the central and peripheral nervous systems from exposure to electromagnetic radiation.

The full set of clinical signs and symptoms is listed in the section on radiation sickness, above.

17. Mechanisms of injury

Shear-strain/closed head injury. Finally the issue of "thermal vs. "non-thermal effects must now be addressed, however reluctantly. The argument has been made by industry representatives that all health effects from microwaves are only due to the excessive heating of the body. These are the same scientists who never do any experiments at low levels of power because they don't expect to find any effects, and they are the same scientists who dismiss all the effects they do find at high levels of power as being due to heating. Since funding for research is largely controlled by these same scientists (see especially Frey 1982 for an excellent account of the situation), they are running a good scam. As can be seen from the review of studies in this report, however, there is nevertheless plenty of good, consistent evidence from more objective researchers that exposes once and for all the fiction these scientists are still trying to maintain.

Even if their conclusions were true, however, their reasoning escapes me. Does a health hazard cease to exist simply because it is labelled "thermal"? "Don't worry," they seem to be trying to tell us, "these microwaves are only cooking you after all!"

But let us look at the physics of the situation. Microwaves produce heat in food and in living organisms by vibrating ions and polar molecules such as water hundreds of millions of times per second. The molecules align themselves with the rapidly alternating electromagnetic field, and the friction from the vibrations produces heat. So that in actual fact microwaves have primarily a direct electromagnetic interaction with our molecules. Heating is only a side effect.

However it is an important side effect, far more important than those scientists have admitted. Microwaves of extremely low intensity are known to cause thermoacoustic pressure waves in the head, including the brain, causing the phenomenon of microwave hearing (see above). This may cause a shear-strain injury in the brain, resulting in axonal tearing and neural degeneration, similar to what occurs in concussion from traumatic injury. Frey (1988) remarks on the similarity between the symptoms of radiation sickness/

electrical sensitivity, and the symptoms of closed head injury or post-concussive syndrome: reduced attention span, impaired complex information processing, memory disturbance, increased emotional lability, irritability, anxiety, and depression. Reference to medical textbooks reveals other similarities, including headache, dizziness, photophobia, respiratory distress, bradycardia, change in blood pressure, cardiac arrhythmias, pupil asymmetry, altered glucose metabolism, and increased caloric demand, all of which have been noted in radiation sickness/electrical sensitivity. Frey comments, "It is ironic that it is such a shear-strain effect in the brain that the engineers concerned with hazards were implicitly assuming when they were trying to explain away the radiofrequency hearing effect as not being an indication of hazard. They never realized that shear-strain due to thermoacoustic expansion in brain tissue would itself damage the brain" (p. 800).

Similar damage, by the same mechanism, might also be responsible for effects on other organs. I am thinking particularly of the testes, which because of their location and size absorb much more microwave radiation than other organs (Copson 1962). Dr. John Holt, for example, speculates on the connection between electromagnetic radiation and the worldwide decline in human sperm count, as well as the recent global decline and extinction of so many species of amphibians (personal communication).

Blood-brain and other barriers. In this regard concussions have been studied experimentally in animals by the creation of pressure pulses induced by the introduction of a small volume of fluid outside the brain membranes through a hole in the skull. These low magnitude pressure waves were found to increase the permeability of the blood-brain barrier (Rinder and Olsson, described in Oscar and Hawkins 1977).

That microwaves at low power also alter the blood-brain barrier has been confirmed. Frey's rats that had avoided exposure to microwaves were also found to have increased permeability of foreign substances into their brain. This occurred after irradiation by both pulsed waves, at 200 uW/cm^2, and continuous waves, at 2.4 mW/cm^2.

Oscar and Hawkins (1977) verified Frey's work and took it farther, demonstrating increased uptake of even very large molecules like dextran, and observing the effect down to 30 uW/cm^2 for pulsed waves and 300 uW/cm^2 for continuous waves. Indeed a biphasic response was observed: uptake of mannitol into the brain increased up to a power level of 1 mW/cm^2 and then decreased at higher intensities. A similar biphasic pattern has been seen by Bawin and Adey for calcium efflux from the brain, and by Balcer-Kubiczek (1994) for cancer from ionizing radiation. It is just such a biphasic pattern that has caused experiments at so-called "thermal" levels of exposure to be erroneously interpreted as contradicting the results of experiments done at "non-thermal" power levels.

Often erroneous interpretation results from simply failing to analyze the data. Thus Merritt et al. reported on their study purporting to show no alteration of barrier permeability from microwaves. "But a statistical analysis of the data presented in their paper by several scientists showed that, in fact, their data supported the opposite conclusion and provided a confirmation of the findings of Frey et al." (Frey 1988, p. 808).

The integrity of other barriers is also compromised by microwaves. In a blood-vitreous barrier experiment (Frey 1988) it was demonstrated that a 25-minute exposure to power densities of 75 uW/cm^2 increased the uptake of sodium fluorescein dye into the vitreous humor of the eye. In this